

APPLICATION

FOR

UNITED STATES LETTERS PATENT

TITLE: PARTITIONING RESPONSIBILITY BETWEEN LINK  
MANAGER AND HOST CONTROLLER INTERFACE  
FIRMWARE MODULES IN WIRELESS SYSTEMS

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Express Mail No. EL911617663US

Date: November 8, 2001

PRITIONING RESPONSIBILITY BETWEEN  
LINK MANAGER AND HOST CONTROLLER INTERFACE  
FIRMWARE MODULES IN WIRELESS SYSTEMS

Background

5        This invention relates generally to wireless  
communication protocols.

10        The Bluetooth wireless protocol utilizes connection  
and link management. See the Bluetooth Specification,  
Version 1.1, February 22, 2001. Bluetooth technology uses  
short-range (10 meter) radio links to replace cable  
connections between a variety of electronic devices.

15        The Bluetooth specification calls for a protocol stack  
that includes a radio layer that forms a physical  
connection interface. A baseband and link manager protocol  
establish and control links between Bluetooth devices. A  
host controller layer interfaces the Bluetooth hardware to  
the upper protocol logical link control and adaptation  
layer (L2CAP). Applications reside above the L2CAP.

20        The baseband layer controls radio communications. The  
handling of packets over the wireless link involves the  
baseband layer. The baseband layer also facilitates the  
synchronization between clocks of connected wireless  
devices. It may also facilitate the inquiry procedures for  
determining addresses of proximate wireless devices.



interface commands for setting and managing links, setting local device attributes, managing link quality, attending to critical events, such as timeouts, and translating L2CAP data packets into baseband packets. The host controller interface and link manager protocol firmware jointly handle all of these functions except translating data packets into baseband packets. The Bluetooth specification details the host controller interface and link manager protocols without specifying how these responsibilities may be partitioned into multiple tasks.

Thus, there is a need for techniques for partitioning the host controller interface and link manager protocol firmware so as to improve the logical separation of their functions, improve efficiency, increase command throughput, or distribute loads across the firmware.

### Brief Description of the Drawings

Figure 1 is a schematic depiction of one embodiment of the present invention; and

Figure 2 is a flow chart showing connection establishment in accordance with one embodiment of the present invention.

### Detailed Description

Referring to Figure 1, a pair of Bluetooth devices 10 may communicate using a wireless protocol. Each device 10

may include an antenna 12 for this purpose. The devices 10a and 10b may be identical, each including a baseband controller 18 that communicates with link manager firmware 20 and host controller interface (HCI) firmware 22.

5 In accordance with one embodiment of the present invention, all host controller interface commands that concern the overall state of the Bluetooth device 10 are processed directly in the host controller interface (HCI) firmware 22. Commands pertaining to each particular link  
10 are processed by the link manager firmware 20. Thus, the state machine is distributed between the firmware 20 and 22. The HCI firmware 22 keeps track of the system wide state of the link controller of the Bluetooth device 10, while the link manager firmware 20 maintains the state of  
15 each link existing in a device 10.

Referring next to Figure 2, the establishment of a wireless connection between the devices 10a and 10b involves a series of handshaking steps between the end points of the communication link. See Bluetooth  
20 specification. The baseband handshake that establishes a physical link 26 precedes the logical link connection 28. The baseband handshake may include the implementation of the inquiry mode wherein each device 10 attempts to determine what access points are in-range. In-range  
25 devices respond to an inquiry from an initiating device

with their addresses. The initiating device 10 selects one of the responding devices with which to communicate.

To establish communications, a paging mode is implemented wherein the devices 10 synchronize with one another. Then, the devices 10 set up a physical layer connection and exchange information about the type of services available from each device.

As indicated in Figure 2, during connection establishment, communication with hardware, including the processing of any possible time-outs, is handled by the host controller interface firmware 22. After the baseband portion of the connection is established, the host controller interface firmware 22 passes control, along with all required information, to the link manager firmware 20 for the establishment of the logical link.

The link manager firmware 20 negotiates the link attributes, such as a packet type, authentication, and encryption preferences, and establishes the logical link. The two Bluetooth devices 10 exchange link manager protocol data units (PDUs) as defined in the Bluetooth specification in order to exchange information on packet types, encryption and the like.

In some embodiments, the partitioning between the host controller interface and link manager firmware 20 and 22 may result in better logical separation of functions, improved efficiency because of fewer message layers, better

command throughput, and more even processing load  
distribution across the firmware 20 and 22. Freeing the  
link manager firmware 20 from the system-wide link  
controller state management may also enable the link  
5 manager protocol to provide a faster response to protocol  
data units received from a link manager protocol of a peer  
device, in some embodiments.

Since the link management manages all the link  
properties busily, its share of the consumption of  
10 processor millions of instructions per second (MIPs) is  
relatively high. Processing inquiry (inquiry response) and  
paging (page response) commands are hardware intensive and  
are relegated to the baseband hardware. Not involving the  
link manager in these operations may improve the overall  
15 performance of the system while bringing down the processor  
MIPS requirement in some embodiments.

While the present invention has been described with  
respect to a limited number of embodiments, those skilled  
in the art will appreciate numerous modifications and  
20 variations therefrom. It is intended that the appended  
claims cover all such modifications and variations as fall  
within the true spirit and scope of this present invention.

What is claimed is: